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The effects of septal surgery on the growth of nose and maxilla

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SUMMARY

Experiments in growing rabbits showed the great importance of the nasal septum for the postnatal growth of the facial skeleton. The influence of surgical procedures on the morphogenetic function of the nasal septum was investigated. The effects of unilateral and bilateral elevation of the muco-perichondrium and of submucous resection of various parts of the septal cartilage on the growth of the nose and upper jaw are demonstrated.

The ear, nose and throat surgeon is often faced with a child with a marked deviation of the septum and its resulting problems, which can be solved in the short term by a septal correction. However, the question must be considered whether the septal operation at childhood disturbs the later development of the nose and the upper jaw.

POSTNATAL DEVELOPMENT OF THE HUMAN SKULL

The skulls of an infant and of an adult do not only differ in size, also the profile of the adult shows differences with the newborn, because the facial skeleton increases more in size during the postnatal growth than the brain-skull and grows furthermore antero-inferiorly. This results in the characteristic profile of the adult face with a more protruding nose and upper jaw. From birth to the adult stage, the base of the (brain) skull – the distance from the nasion, lying on the fronto-nasal suture, to the posterior edge of the foramen magnum – increases by a factor of about 1.5. In the same period the bridge of the nose becomes 3 times as long and the height of the nose – the distance between the nasion and the upper surface of the palate – 2.5 times as large. The extra growth of the facial skeleton in the postnatal period is demonstrated in Figure 1, where the brainskulls of a newborn and an adult are reduced to approximately the same size.

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The speed of growth of the skull changes with increasing age (Björk, 1955). It is high immediately after birth and decreases to a minimum before puberty. After that the adolescent growth spurt occurs, which is followed by a gradual decrease of growth up to the adult stage (Figure 2). The facial skeleton continues to grow for a longer period than the brainskull.

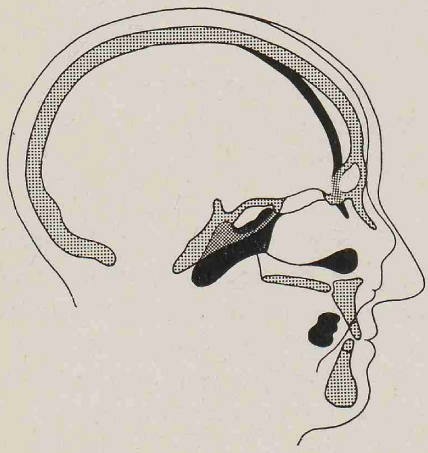

Figure 1. Sagittal section of the head of a newborn and an adult after reducing the brainskull of both to approximately the same size. In comparison to the brainskull the facial skeleton shows an extra growth during postnatal development.

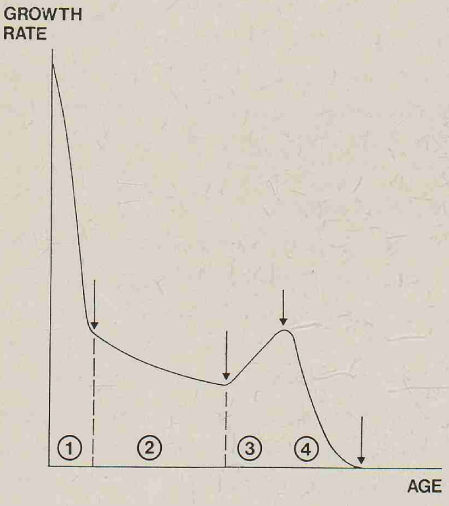

Figure 2. Evolution of the growth-rate of the skull: high immediately after birth (1), decreasing (2) to a prepuberal minimum, increasing (3) to an adolescent growth spurt, gradually decreasing (4) up to the adult stage (modified after Björk, 1955).

The following points may be noted on this growth curve.

1. If an operation is carried out on the nasal septum during the period of slow growth, the effect may only declare itself several years later, during or after the adolescent growth spurt.
2. The influence of a septal operation on the morphogenesis of the facial skull may depend on the speed of growth, be it lesser or greater to the timing of the operation.

THE SEPTAL CARTILAGE IN THE POSTNATAL DEVELOPMENT OF THE MIDFACE

Experimental results of Sarnat and Wexler (1967 A, 1967 B), Ohyama (1969), Kremenak and Searles (1971) and Kvinnsland (1974) suggested an important role of the nasal septum in the morphogenesis of the nose and the upper jaw. However, according to Moss et al. (1968) and Stenström and Thilander (1970) the septal cartilage is not a primary growth-centre in the midface but acts only as a supporting "frame" of the nose.

Recent studies of the skull growth in rabbits (Mastenbroek, 1978 and Verwoerd et al., 1979) demonstrated that the growth of the facial skeleton depends to a large extent on the growth of the septal cartilage. After partial resection of the septal cartilage, disturbing its antero-posterior continuity, the growth rate of the facial skeleton decreases to the level of the brain skull and the extra growth of the nose and maxilla are not observed (Verwoerd et al., 1979).

Concerning the effects of surgical procedures, as applied during septal correction, on the morphogenetic function of the septal cartilage, no experimental data are available. Studies of the growth of the skull after septal correction at childhood are also scarce and usually do not cover a period long enough to show the late effects on the skull-growth after the adolescent growth spurt.

For the treatment of septal deformities in children it is important to investigate which surgical procedures do and which do not disturb the further development of nose and upper jaw. To provide a rational basis for the treatment of septal pathology in children experimental studies were performed.

The rabbit was chosen as an experimental animal, because its growing skull previously appeared to be a suitable model for studying the growth of the

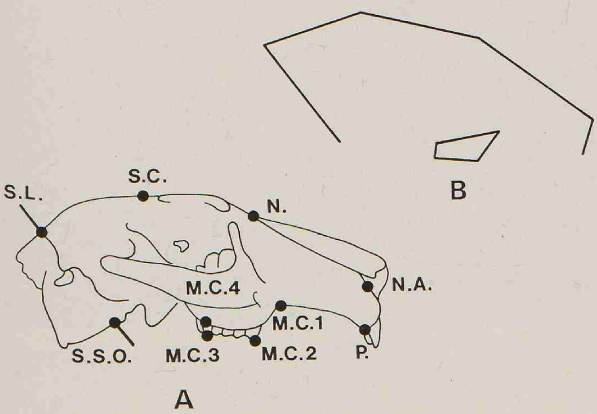

Figure 3a.
Measuring points on the lateral side of the skull of a rabbit: SSO (spheno-occipital synchondrosis), SL (lambdoid suture), SC (coronary suture), N (nasion), NA (nasal aperture), P (premaxilla), MC 1, MC 2, MC 3, MC 4 (molar complex).
Figure 3b.
Diagram, representing the statistical average of the co-ordinates of the measuring points.

facial skeleton under normal and abnormal conditions (Verwoerd-Verhoef, 1974; Urbanus, 1974; Verwoerd et al., 1976).
The skulls of the rabbits were studied morphologically and geometrically. For the last purpose 10 points were determined on standardized photographs of the lateral side of the skull (Figure 3a). The points were measured in a rectangular coördinate system with SSO - SL as ordinate and the perpendicular line in SSO as abscissa. The points represented in the diagrams are based on the statistical average of the coördinates of the experimental series (Figure 3b).

NORMAL GROWTH OF THE SKULL OF THE RABBIT

Series of skulls of rabbits, aged 1 day, 1, 2, 3, 4, 6, 8, 10, 12, 16, 20 and 24 weeks were studied by Urbanus et al. (1977). The diagrams of the skulls are illustrated in Figure 4. It is evident that the facial skull increases relatively more in size than the brainskull and grows anteriorly. Moreover the facial skeleton continues to grow for a longer period than the brainskull.

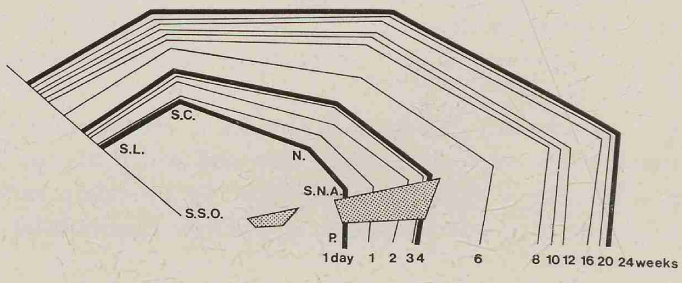

Figure 4. Diagrams of the skulls in 12 age groups. Reference point: SSO, reference line: SSO-SL. The dotted parts represent the molar complex in rabbits, aged 1 day (left) and 24 week (right).

The cartilaginous part of the nasal septum in the rabbit, as in the child, extends as far as the sphenoid and reaches anteriorly the premaxilla. The premaxilla and the vomer form a bony guther in which the cartilaginous septum sits.

EXPERIMENTS

The experimental operations were performed in the 4th week after birth. Twenty weeks later the skulls of the adult animals were studied. In the diagrams the skulls of the 24 week old experimental animals are compared with control animals of the same age.

Series 1

Opening and closing of the nasal cavity, as necessary for the septal operations in the other experiments, was done by an incision of the skin on the left

side of the nose and lifting a part of the left nasal bone in the 4 week old animals. This procedure does not result in serious growth disturbances of the nose and upper jaw. It caused only slight anomalies restricted to the left nasal bone in the adult animals (Mastenbroek, 1978).

Series 2

If a tunnel is made beneath the mucoperichondrium on one side of the nasal septum at the age of 4 weeks, the effects on the further development of the midface are relatively insignificant. Compared to the adult control animals, the upper jaw and nose of the experimental series are equal in size and the molar complexes maintain a similar position (Figure 5).

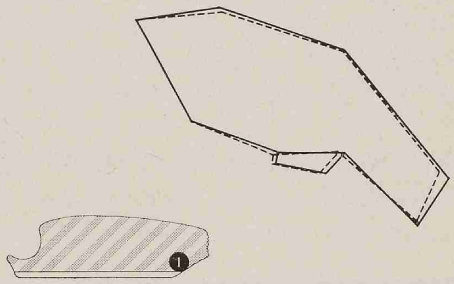

Figure 5. Diagrams of the skulls of adult animals after applying a normalising procedure according to SSO-SL; interrupted line: series 2 (tunneling of the mucoperichondrium on one side of the nasal septum); full drawn line: control series.

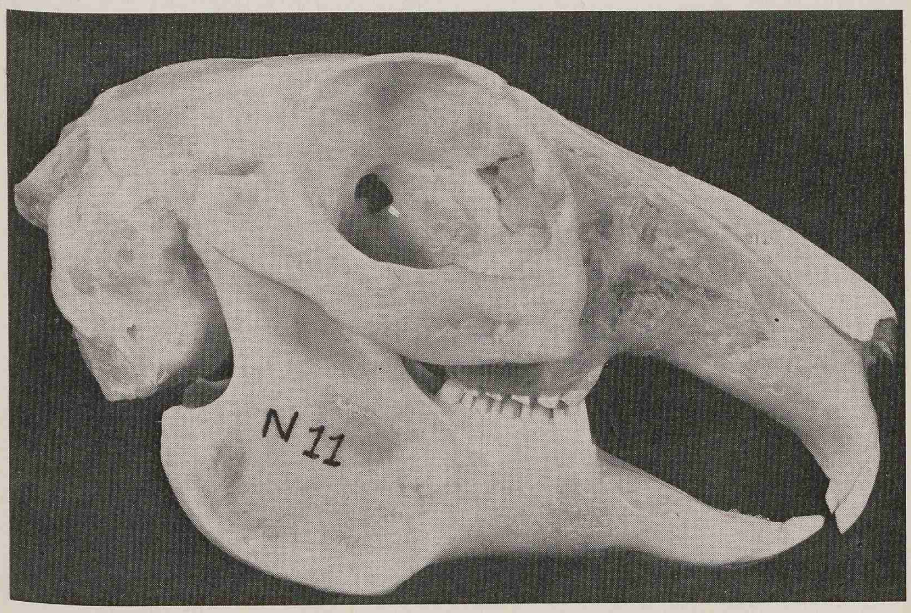

Figure 6. Lateral side of the skull of an adult rabbit after tunneling the mucoperichondrium on both sides of the nasal septum at the age of 4 weeks (series 3): normal profile.

Series 3

Also bilateral undermining of the mucoperichondrium of the nasal septum does not disturb the growth of the nose and upper jaw. Both are not shortened in the adult stage. The molar complexes are in a similar position as in the control animals of the same age (Figure 6).

Series 4

Quite different are the effects of submucous resection of the middle third of the septal cartilage. Then a considerable disturbance of the development of the midface is observed. Nose and upper jaw grow out straight but are clearly too short in the adult animals (Figure 7). The bridge of the nose is saddle-shaped. The quantitative study reveals not only a very foreshortened upper jaw, but also a retroposition of the molar complex compared to the control series (Figure 8). In fact this submucous interruption of the antero-posterior continuity of the septal cartilage has the same effects on the development of the midface as was observed after resection of the middle third of the septum including the mucoperichondrium (Mastenbroek, 1978; Verwoerd et al., 1979).

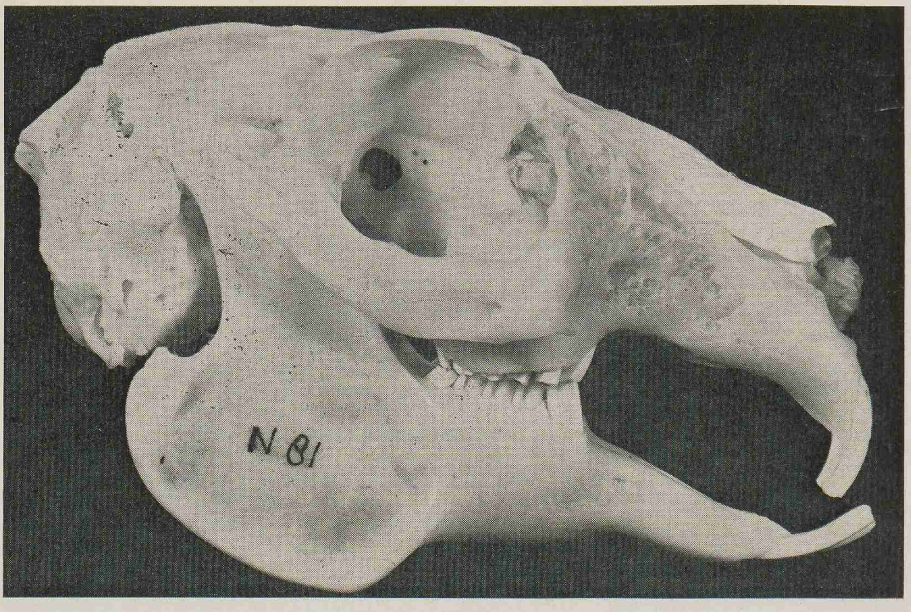

Figure 7. Lateral side of the skull of an adult rabbit, in which at the age of 4 weeks the antero-posterior continuity of the septal cartilage was interrupted by submucous resection of its middle third (series 4): shortening of the saddle shaped nasal bones and of the maxilla, frontal malocclusion.

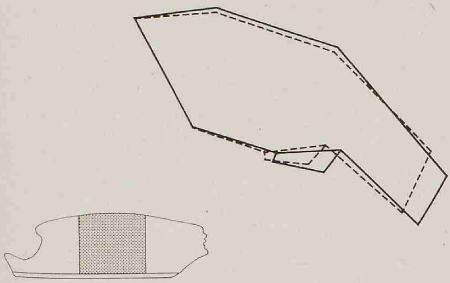

Figure 8. Diagram of the skulls of adult rabbits after applying a normalising procedure according to SSO-SL; interrupted line: series 4 (submucous resection of middle third of septal cartilage at the age of 4 weeks); full drawn line: control series.

Series 5

If only a basal strip of the septal cartilage is removed submucously, the results are also as marked (Figure 9). At the adult stage the upper jaw and nose are too short. The nose is underdeveloped in its height. The diagram demonstrates a foreshortening of the upper jaw and retroposition of the molar complex (Figure 10).

The remaining part of the septal cartilage with its undisturbed antero-posterior continuity cannot stimulate the outgrowth of the nose and upper jaw, probably because it was deprived of its connection to the premaxilla. Nevertheless

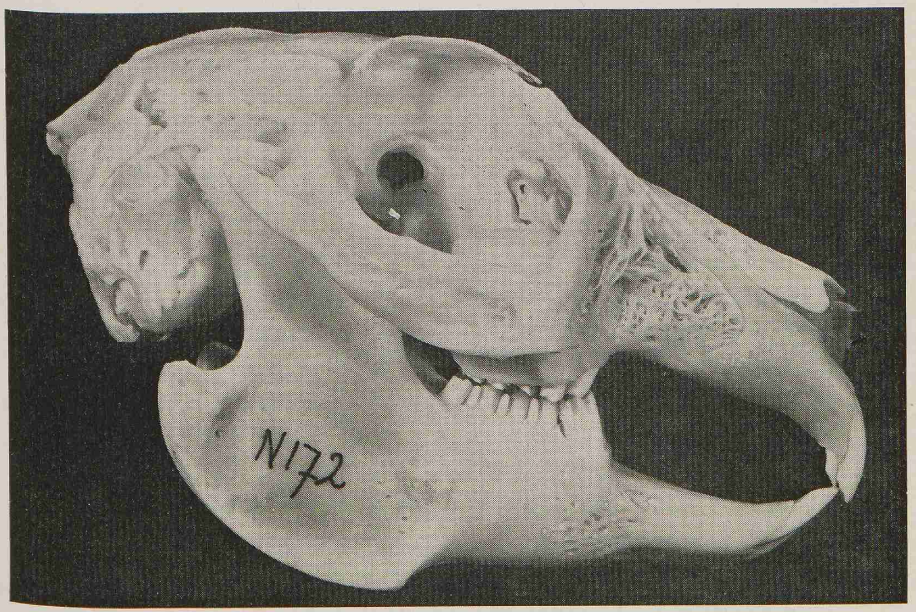

Figure 9. Lateral side of the skull of an adult rabbit after submucous resection of a basal strip of the septal cartilage at the age of 4 weeks: shortening of the nasal bones, maxilla and mandible.

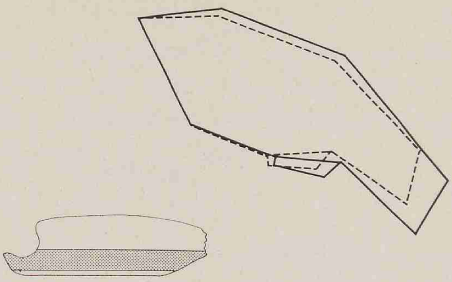

Figure 10. Diagram of the skulls of adult rabbits after applying a normalising procedure according to SSO-SL; interrupted line: series 5 (submucous resection of basal strip of the septal cartilage at the age of 4 weeks); full drawn line: control series.

the remaining septal cartilage grows, which results in a "harmonica" configuration, because the basal side of the septum is not held in the midline by the bony guther of the vomer and premaxilla.

Series 6

If the antero-posterior continuity of the septal cartilage is only interrupted by a submucous resection of a 1 mm broad zone of cartilage, perpendicular to its antero-posterior axis, no statistically significant foreshortening of the nose and maxilla is observed in the adult animal (Figure 11). The continuity of these septa is restored spontaneously, but in most animals a sharp deviation develops at the place of the former resection. Consequently, the nose and maxilla of these animals show a deviation to the left or right (Figure 12).

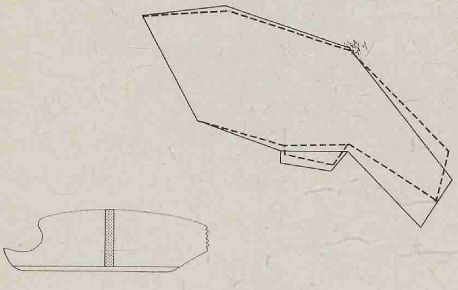

Figure 11. Diagrams of the skulls of adult rabbits after applying a normalising procedure according to SSO-SL; Interrupted line: series 6 (after interrupting the antero-posterior continuity by submucous resection of a 1 mm broad zone of cartilage); full drawn line: control series.

CONCLUSIONS

The experiments showed the following:

1. Unilateral or even bilateral tunneling of the septal mucoperichondrium has no significant effects on the growth of the nose and maxilla.
2. The basal strip of the cartilaginous septum is very important for the outgrowth of the midface. The gripping of the cartilaginous septum by the bony groove of the vomer and premaxilla seems to prevent harmonica-like deformation of the growing septal cartilage and subsequent decreased total length of the nose.

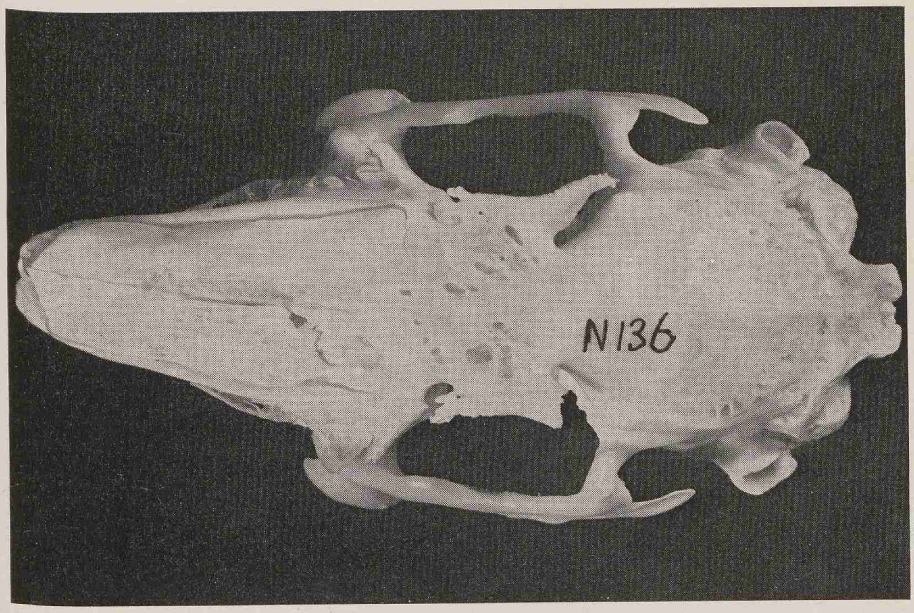

Figure 12.
Dorsal view of an adult skull of series 6: deviation of nasal bones and maxilla associated with a deviation of the nasal septum.

3. Broader interruptions of the antero-posterior continuity of the septal cartilage caused a foreshortening of nose and maxilla without deviation. Smaller interruptions of the septal cartilage, which spontaneously heal, do not interfere with the total length but cause asymmetries of the nose and maxilla.

The results of this first series of experiments do not show that septal surgery is absolutely contra-indicated in childhood but do emphasise the dangers for the later shape and function of the nose and upper jaw. The aim of a septal correction in children must be an immediate restoration of form and function, and of the anatomical conditions necessary for a normal development of the facial skeleton.

The outcome of the experimental series stress:

1. The importance of the basal part of the cartilage, its fixation to the premaxilla (spina nasalis anterior) and to the sphenoid and the perpendicular plate of the ethmoid.
2. The role of the bony guther formed by vomer and premaxilla in preventing deviation and diminished length of nose and upper jaw.
3. The abnormal development of the nose and upper jaw caused by discontinuities in the septal cartilage.

ZUSAMMENFASSUNG

Tierexperimentell wurde festgestellt, dasz die Nasenscheidewand von grösster Bedeutung ist für das postnatale Wachstum des Gesichtsschädels. In weiteren Experimenten wurde untersucht, wie ein- oder doppelseitiges Untertunneln der Schleimhaut und submuköse Resektion von verschiedenen Teilen des knorpeligen Septums die Entwicklung der Nase und des Oberkiefers beeinflussen.

RÉSUMÉ

Le septum nasal est très important pour le développement harmonieux du crâne facial dans la période postnatale. Les résultats des expériments démontrent l'influence de l'élévation uni- et bilaterale du muco-périchondrium et d'une résection des parts différents de la cartilage septale sur le développement du nez et du maxilla.

REFERENCES

1. Björk, A., 1955: Facial growth in man, studied with the aid of metallic implants. Acata, odont. Scand. 13, 9.
2. Kremenak, C. R. and Searls, J. C., 1971: Experimental manipulation of midfacial growth: A synthesis of five years of research at the Iowa Maxilla facial growth laboratory. J. Dent. Res. 50, 1488-1491.
3. Kvinnsland, S., 1974: Partial resection of the cartilaginous nasal septum in rats; its influence on growth. Angle Orthodont. vol. 44, no. 2, 135-140.
4. Mastenbroek, G. J., 1978: The influence of partial resection of the septal cartilage upon maxillary and nasal growth. Thesis Amsterdam.
5. Moss, M. L., Bromberg, B. E., Song, I. C. and Eisenman, G., 1968: The passive role of nasal septal cartilage in mid-facial growth. Plast. Reconstr. Surg., 536-542.
6. Ohyama, K., 1969: Experimental study on growth and development of dentofacial complex after resection of cartilaginous nasal septum. Bull. Tokyo Med. Dent. Univ. 16, 157-176.
7. Sarnat, B. G. and Wexler, M. R., 1967 A: The snout after resection of nasal septum in adult rabbits. Arch. Otolaryng. 63, 463-466.
8. Sarnat, B. G. and Wexler, M. R., 1967 B: Rabbit snout growth after resection of central linear segments of nasal septal cartilage. Acta Otolaryng., 467-478.
9. Stenström, S. J. and Thilander, B. L., 1970: Effects of nasal septal cartilage resections on young guinea pigs. Plast. Reconstr. Surg., vol. 45, no 2, 160-170.
10. Urbanus, N. A. M., 1974: Skull growth after closure of artificial clefts of lip, alveolus and palate. An experimental study on the effects of some surgical methods in the rabbit. Thesis, University of Amsterdam.
11. Urbanus, N. A. M., Verwoerd, C. D. A., Tonneyck-Müller, I, Verwoerd-Verhoef, H. L., 1977: A quantitative study of the growth of the skull in rabbits. Acta Morphol. Neerl. Scand. 15, 335.

12. Verwoerd-Verhoef, H. L., 1974: The influence of artificial clefts on the growth of the skull in young rabbits. Thesis, University of Amsterdam.
13. Verwoerd, C. D. A., Verwoerd-Verhoef, H. L., Urbanus, N. A. M., 1976: Skulls with facial clefts. Acta Otolaryngol. 81, 249-256.
14. Verwoerd, C. D. A., Urbanus, N. A. M., Verwoerd-Verhoef, H.L., 1979 (in press): Growth-mechanisms in skulls with facial clefts. Acta Otolaryngol.

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